Trinity Consultants

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September 29, 2009

Ms. Victoria Wagner
Spectra Energy Transmission, LLC
P.O. Box 1642
Houston, Texas 77251

Dear Ms. Wagner:

This letter report summarizes the air dispersion and deposition modeling analysis conducted by Trinity Consultants (Trinity) in response to an emergency shutdown (ESD) in the compressor building at the Steckman Ridge, LP facility located at 1809 Rock Hill Church Road just east of Clearville, Pennsylvania. This ESD resulted in the contemporaneous depressurization of the whole system over about a 90 second period of time and the release of methane and lubricating oil in the form of oil mist particles from one or more ESD discharge points at the facility. Trinity was retained by Steckman Ridge, LP to perform a modeling analysis for the ESD for the purposes of discerning the likely path of the released oil mist, and determining the potential direction and distance to which oil mist may have propagated.

MODELING SUMMARY

At approximately 2:10 PM eastern daylight time on Sunday, August 23, an ESD of the Steckman Ridge compressor station near Clearville, Pennsylvania occurred. The ESD involved the controlled venting lasting about 90 seconds of pipeline-quality natural gas from piping and equipment at the facility through several vent pipes.

Some quantity of the natural gas vented passed through a separator that captures lubricating oil from the gas compressors. Due to the very high velocity of the vented gas as it traveled through the separator and piping system, oil was entrained in the gas as fine particles. The combination of gas and entrained oil particles was vented vertically from the vent pipes and was transported downwind.

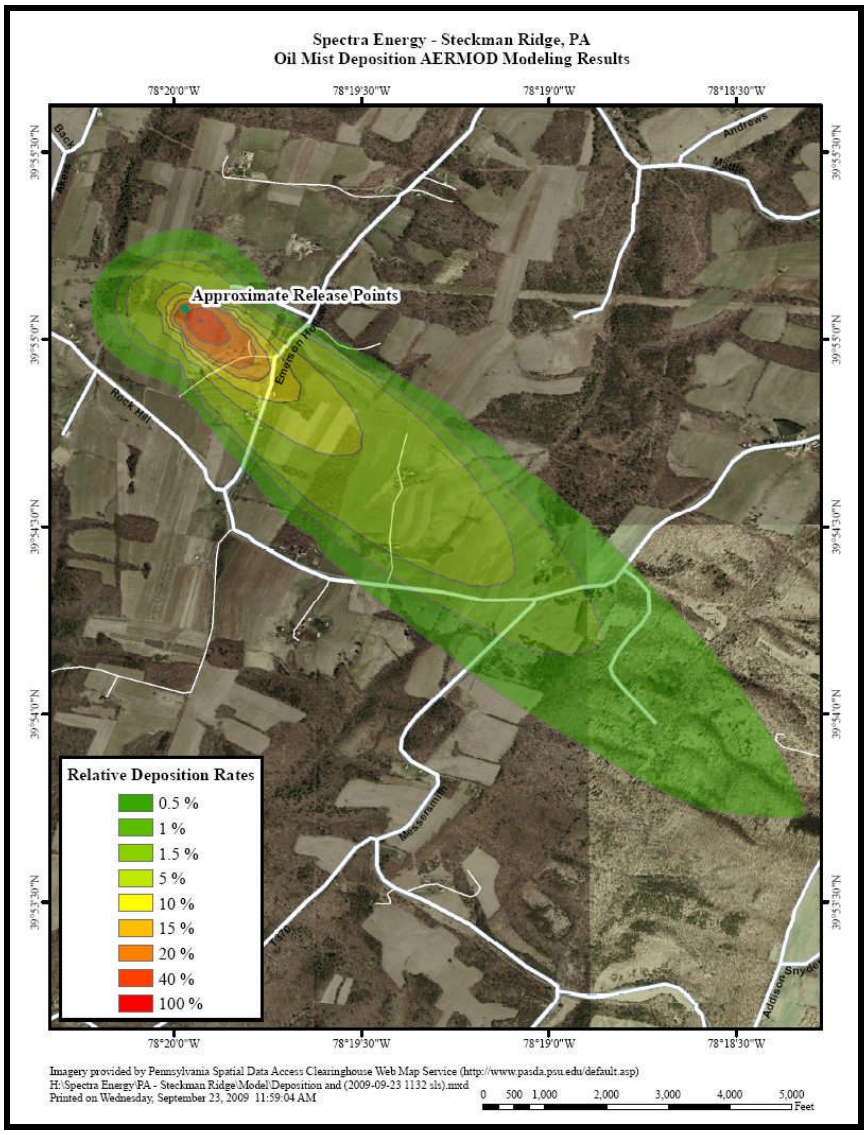
Oil associated with the release was noted to have been deposited on surfaces in the immediate vicinity of the vent stacks, and was observed to have been deposited on certain surfaces located on or near a line to the south east of the vent pipes and at distances of up to approximately one mile away.

Trinity conducted dispersion modeling using gas release data and local meteorology to estimate the shape and direction taken by the plume containing the oil droplets. This modeling was used to predict the relative deposition of oil droplets at the ground surface, which was assumed to correlate with the rate of deposition of oil on the ground or other surfaces, along the direction of travel of the plume. Trinity used AERMOD, a preferred US EPA air dispersion model, and wind

speed and direction data from local meteorological stations to estimate the above parameters. AERMOD was chosen because it has the fundamental capabilities to model such plumes and the associated particle deposition. However, due to the dynamic and variable nature of the release, Trinity chose to report the modeling results in relative, rather than absolute terms. Meteorological data obtained from a site to the north of the point of release indicated that from approximately noon until 5:30 PM that day the wind was blowing consistently from the northwest at average wind speeds of 4-8 miles per hour.

Results of the modeling, which are presented graphically in Figure 1, indicate that the plume would have expanded modestly at the point of release (due to the high release velocity from the vent) before being transported in a southeasterly direction by the prevailing winds. The highest ground level concentrations of oil droplets were estimated to occur immediately downwind of the point of release. The estimated relative rates of deposition are shown in Figure 1 as colored contour intervals trending downwind from the point of release. The model predicted that the rate of deposition would have decreased to approximately 10 percent of maximum within approximately 3,440 feet downwind from the site, and approximately 1 percent of maximum by approximately 8,300 feet downwind of the site.

FIGURE 1. OIL DROPLET RELATIVE DEPOSITION CONTOURS



The results are supportive of various observations of oil deposition made in the field by Steckman Ridge personnel, particularly in the direction of travel. The model results indicate that the relative rates of deposition in directions other than downwind of the point of release are predicted to be very low to virtually zero at distances of approximately 1,000 feet or more from the point of release.

The data and assumptions used in conducting the modeling are described in greater detail in the remainder of this letter report.

DESCRIPTION OF RELEASE

At approximately 2:10 PM eastern daylight time on Sunday, August 23, an emergency shutdown (ESD) of the Steckman Ridge, LP compressor station near Clearville, Pennsylvania occurred. The ESD involved the controlled venting of pipeline-quality natural gas from piping and equipment at the station through several vent pipes located in the facility. Facility personnel report that venting occurred for approximately 90 seconds, wherein portions of the facility were vented from pressures ranging up to approximately 2,200 psig to atmospheric pressure.

Some quantity of the natural gas that was vented first passed through a separator that captures lubricating oil that escapes in small quantities from the gas compressors during operation. At the time of venting the separator contained a volume of lubricating oil (assumed to be 200 gallons which is the maximum oil capacity of the separator but believed to be much less than that amount). An unknown portion of the oil in the separator was entrained into the gas as it passed through the separator, and was carried into facility piping and ejected from the vents during the ESD.

Due to the very high velocity of the vented gas as it traveled through the separator and piping system, the oil was entrained in the gas stream as droplets with a distribution of sizes, all less than 1.0 μm. The size distribution and rate at which the oil exited the vent stacks would have been a function of the velocity of the gas flowing through the system being vented.

The combination of gas and entrained oil droplets were vented vertically from the vent pipes at velocities that ranged from supersonic (in the initial seconds of the release) to near zero (in the final seconds of the release). The vertical jet expanded in diameter as it rose from the stack due to the decrease in pressure and due to the resistance to upward motion provided by the atmosphere. At some point where the velocity of the plume exiting the vents became on the same order as the velocity of the wind in the volume of air containing the plume, the plume ceased to expand in an upwind direction and began to be transported downwind.

The fate and transport of the oil droplets would have depended primarily on the droplet size. Large droplets would be expected to settle out of the plume in the vicinity of the vents. Droplets of an intermediate size would have been expected to settle slowly enough to cause them to be transported some distance downwind before settling on surfaces (e.g., the ground, vegetation, structures, etc.). There is evidence that droplets in this size range may also coalesce in the air to form larger droplets under the right conditions (e.g., concentration, physical properties). Droplets that were small and light enough could have been transported into the atmosphere where they could have been dispersed to the extent that they would not coalesce and could remain aloft until they evaporate or are removed by other mechanisms.

Release Characteristics and Parameters

Most of the gas released was assumed to be methane. Information on the conditions of the methane and oil mist in the station compressors and pipeline system at the time of the release was provided by Steckman Ridge, LP to Trinity and is summarized in Table 1. All materials were assumed to be emitted vertically from the one 6 inch vent pipe with a 4 inch reducer attached to the open end, having an exit elevation of 12.58 feet above ground surface.

TABLE 1. RELEASE INFORMATION

Parameter	Methane	Lube Oil
Total Release Quantity (lbs)	6,460	1,629
Release Duration (sec)*	90	90
Release Temperature (°F)	95	95
Release Point Diameter (in.)	4.0	4.0
Material Density (lb/ft^3)	5.83	60.9
Release Height (ft)	12.58	12.58
UTM coordinates of Vent[a]	E=727942m	N=4422087m

a In NAD83, Zone 17

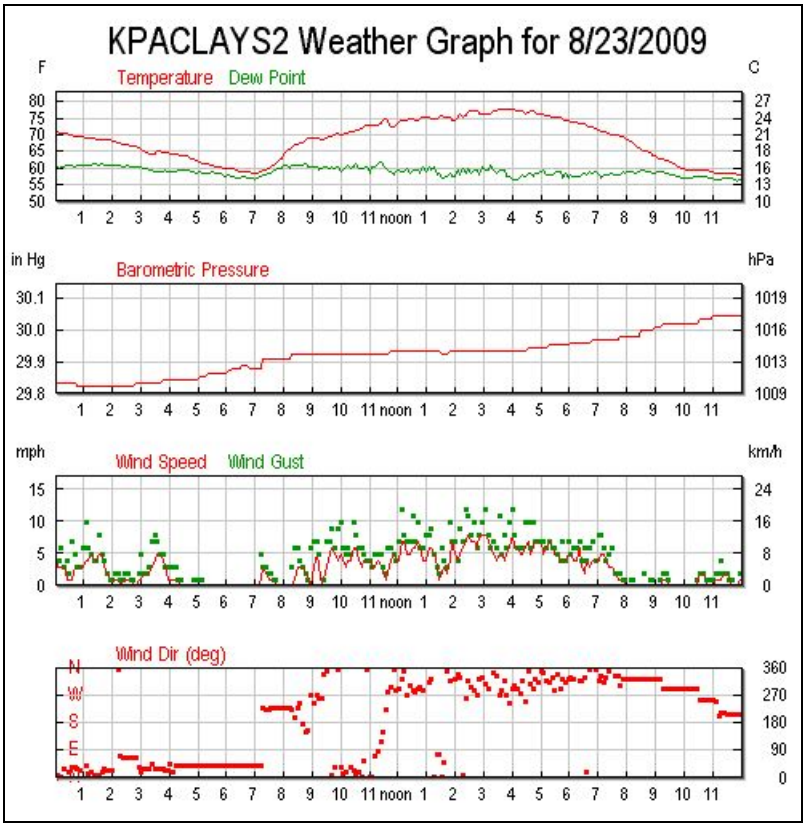
A vent stack gas exit velocity was calculated using the CHARMED[1] Program which calculates the flow velocity for such high pressure releases. With the combined flows of methane and oil mist, an exit velocity of 174 m/s was calculated that would persist until the pressure began to drop after 90 seconds. The worst case total of 200 gallons of lubricating oil was assumed to be emitted from the facility. The emission rate of the oil was adjusted to be consistent with the one hour time increment calculated by AERMOD (200 gallons over 3600 seconds). The particle size of the oil droplets was chosen to be four particle size categories all below 1.0 μm. This assumption is consistent with references indicating that submicron particles would be present in compressor lubrication activities and generated by interaction of oil and high velocity gas jets.

Meteorological Conditions

The meteorological situation at the time of the release affected the direction to which airborne oil droplets would likely be transported and the extent to which they dispersed while being transported. A review of local and regional meteorological data sets for the time of release and the period immediately thereafter, determined that data were being measured and recorded at the weather station located in Claysburg, Pennsylvania about 30 miles north of the Steckman Ridge site. Data for this site were available through an internet weather site called WeatherUnderground at http://www.wunderground.com/weatherstation/WXDailyHistory.asp?ID=KPACLAYS2&month=8&day=23&year=2009. A summary of the data for August 23, 2009 for Claysburg is shown in Figure 2.

[1] CHARMED

FIGURE 2. WEATHERUNDERGROUND DATA FOR CLAYSBURG, PA FROM AUGUST 23, 2009



The specific data for the period of 2:00 – 3:00 pm (1400 hours-1500hours) time on that day are shown in Table 2.

TABLE 2. DATA FOR 1400-1500 HOURS ON AUGUST 23, 2009 FOR CLAYSBURG

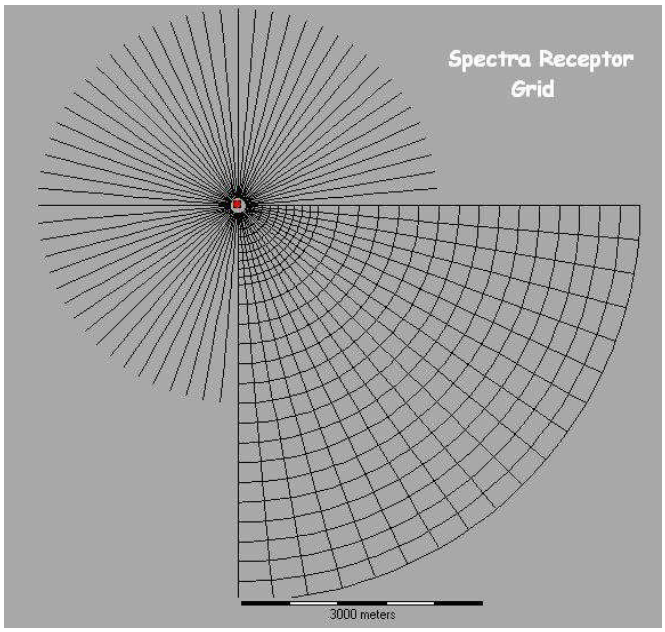
Time	Temperature, F	Dewpoint, F	Pressure, In	WindDirection, Degrees	WindSpeed, MPH	Precip, in
8/23/2009 13:59	74.9	58.1	29.93	326	5	0
8/23/2009 14:05	75.8	60	29.93	342	4	0
8/23/2009 14:11	76.7	58.3	29.93	332	5	0
8/23/2009 14:17	76	60.2	29.93	368	6	0
8/23/2009 14:23	76.5	59.1	29.93	264	7	0
8/23/2009 14:28	77.4	60.5	29.93	320	8	0
8/23/2009 14:34	77.6	59.1	29.93	298	7	0
8/23/2009 14:39	77.6	59.6	29.93	291	7	0
8/23/2009 14:45	77.7	59.7	29.93	275	6	0
8/23/2009 14:51	77	58.6	29.93	328	8	0
8/23/2009 14:57	76.8	60.9	29.93	330	8	0
Hourly averages	76.7			316	6.5	0

To put these data in the correct format for the AERMOD Model, the data must be pre-processed through the meteorological data program called AERMET. AERMET cannot, however, process

data in the format and style of that in Table 2. To do this a full year of a nearby surface meteorological data of the National Weather Service, namely, the site at Middletown, Pennsylvania (NWS 14711) was used to create a single day of input data for AERMET. All values for the 1400-1500 time period in Table 2 were averaged to obtain the hourly average meteorological variables. These were entered into the Middletown data set as well as at the lowest level of an upper air data set from the Pittsburgh, Pennsylvania airport (NWS 94823). The only valid hour in the calculations with regard to the Steckman Ridge release was 1400 hours. Cloud cover was estimated to be 10% opacity from the time of day and general weather conditions.

These data were used along with the AERMOD Model to perform calculations for the methane/oil mist release. AERMOD is an EPA model preferred in the U.S. EPA *Guideline on Air Quality Models* (Appendix W to 40 CFR Part 51[2]). All inputs for the model including source characterization, regulatory options, receptors, meteorological data formats, terrain elevations, and land use characterizations were generated following the general guidance of the Guideline and the AERMOD Implementation Guide.[3] Receptors were set up in an array that allowed the consideration of the major flow to the southeast of the facility and any widespread dispersion in any direction. Figure 3 shows the receptor grid used in the modeling.

FIGURE 3. STECKMAN RIDGE RECEPTOR GRID FOR AERMOD



[2] *Guideline on Air Quality Models*, 40 CFR Part 51, Appendix W.

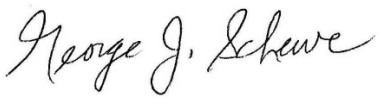
[3] *AERMOD Implementation Guide*, U.S. Environmental Protection Agency, 2009.

These modeling parameters, assumptions, and techniques were used together to calculate the likely path and extent of the oil droplets released by the ESD at the Steckman Ridge, LP facility.

If you have any questions or comments about the information presented in this document, please do not hesitate to call me at (859) 341-8100.

Sincerely,

TRINITY CONSULTANTS



George J. Schewe, CCM, QEP
Principal Consultant

cc: John Wilcox, P.E.